LANDFILL PROFILING
FOR
GAS, LIQUIDS AND VACUUM
&
ENHANCED STEAM BIOREACTORS

STI Engineering
By
Reg Renaud

Compliance Objectives

- Verify The Cause Of Non-Compliance, Surface Emissions, Groundwater, Or Perimeter Probes
- Conduct Integrity Test On Perimeter Probes In Question
- Determine The Elevation Of The Pathway Of Migrating LFG
- Perform PPT Profile Targeting These Specific Elevations
- Install LFG Collector Or Internal Conduit To Mitigate Migration Pathway

Results of Probe Integrity Tests

PROBE	DEPTH (ft)	INITIAL PRESSURE (IN.WC)	METHANE CONCENTRATION By GEM500 (%)	NITROGEN PRESSURE APPLIED (IN.WC)	PRESSURE READING DURING NITROGEN APPLICATION (IN.WC)
MP-9R	30	0	0	--	1.0
	50	0.15	0.2	--	1.0
	89	0	0	--	1.0
	116	0	0	1.0	1.0
MP-14	16	0	0	--	1.0
	33	0	0	--	1.0
	48	0	0	--	1.0
	64	0	0.1	1.0	1.0

Technology Application

- **Established Technology Being Used In A New Application: Piezo- Penetrometer Test (PPT)**
  - Geotechnical Applications for Over 30 Years
  - ASTM Procedures
  - CPT Used for Soil Behavior Type, Density, Strength
  - Piezo-Cone Pressure Used for Water Table Depth, Excess Pore Pressure in Clays

Technology Application

- **Established Technology Being Used In Landfills:**
  - Data on Foundation Conditions, Sand Layers
  - Information on “Relative Refuse Density”
  - Rapid Data on Liquid Zones: Both Horizontal and Vertical
  - Rapid Data on LFG Pressure Zones: Both Horizontal and Vertical
  - Data on Extent of Vacuum from Existing LFG Extraction Systems: Both Horizontal and Vertical

Technology Application

- **Established Technology Being Used In Landfills:**
  - Directly Useful in Design/Modification of LFG and Liquid Extraction Systems
  - Selective Well Location and Screening Based on Field Data
  - Push-in Wells, Perimeter Probes and Steam Injectors are Fast and Economical

Description

- CPT and PPT Used to Characterize Subsurface Conditions

Description

- CPT Indicates Material Strength/ Density and Behavior Type: Cover Layers vs MSW
- PPT Indicates Liquid and/or LFG Pressure

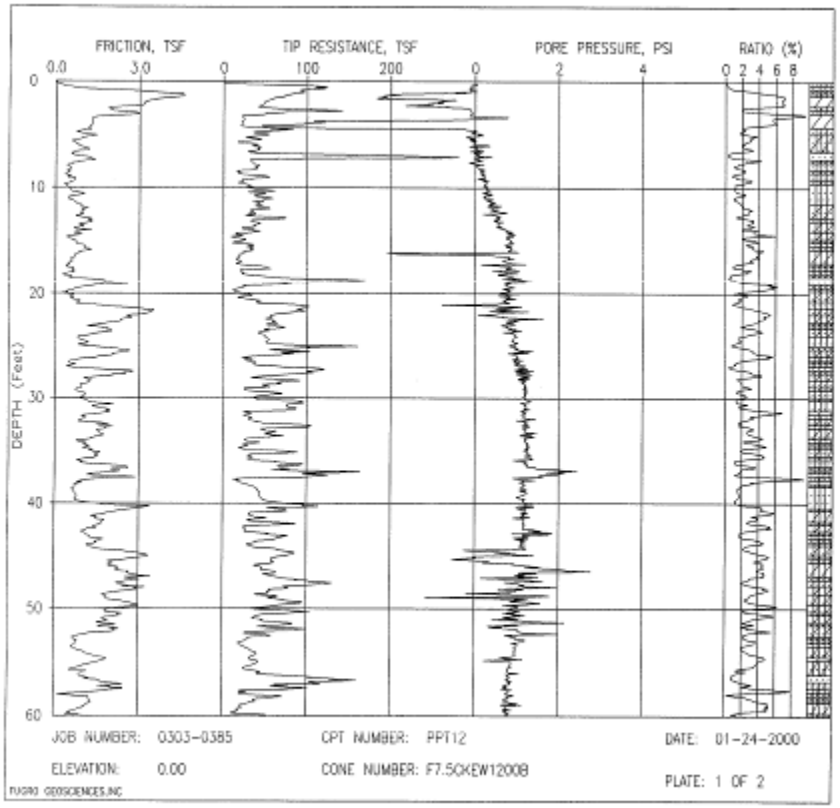
- Field Review of Data to Select Push-in Gas Well Locations and Screen Intervals

Interpretation of PPT Logs

- Identify Dense/Daily Cover Layers
- Distinguish Liquid and Gas Pressures
- Identify Zones of Vacuum
- Evaluate Zones of Low Density MSW
- Determine The Density Of Bottom Native Soils In Unlined Landfills

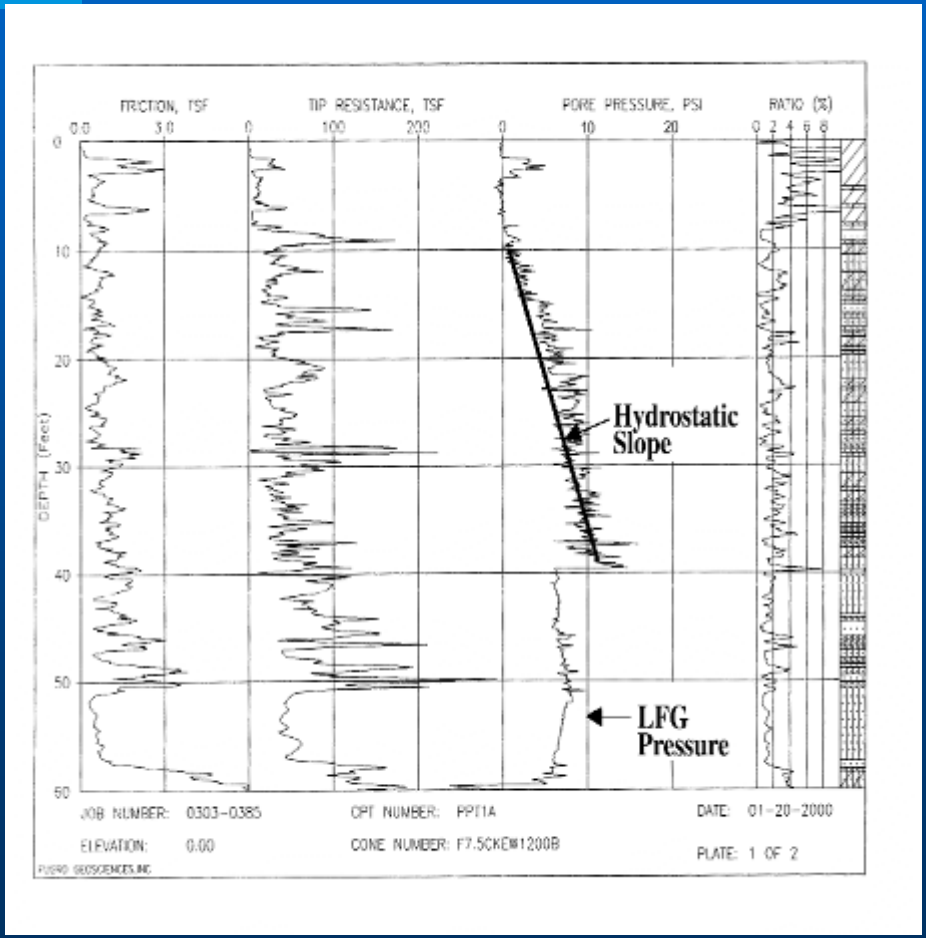
TYPICAL PPT LOG

- Column 1-Depth, ft.
- Column 2-Friction, tsf
- Column 3-Tip Resist., tsf
- Column 4-Pore Pres., psi
- Column 5-Friction Ratio %
- Column 6-Lithology

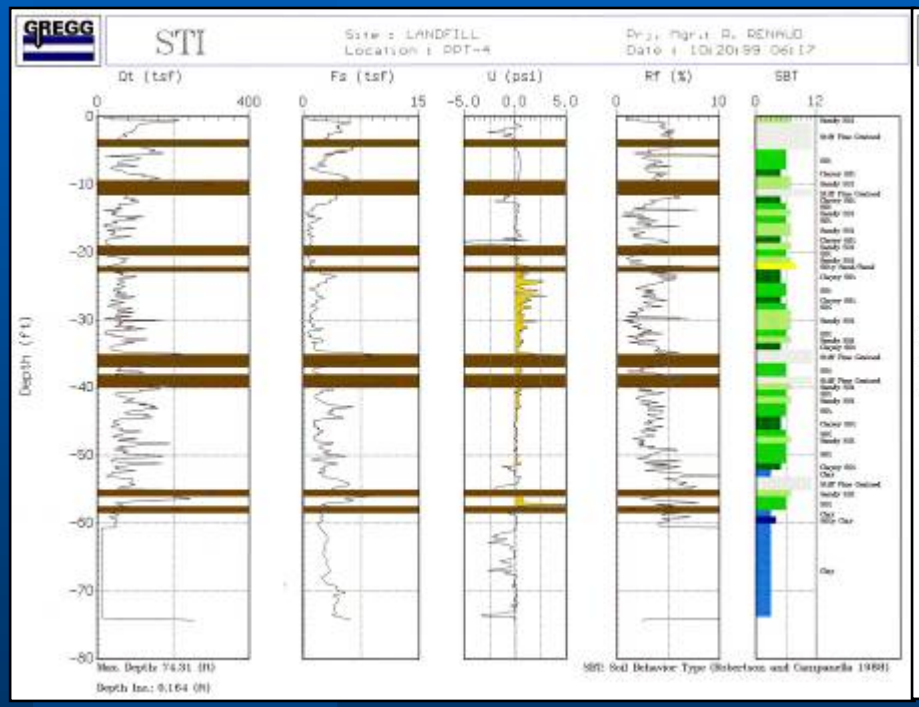


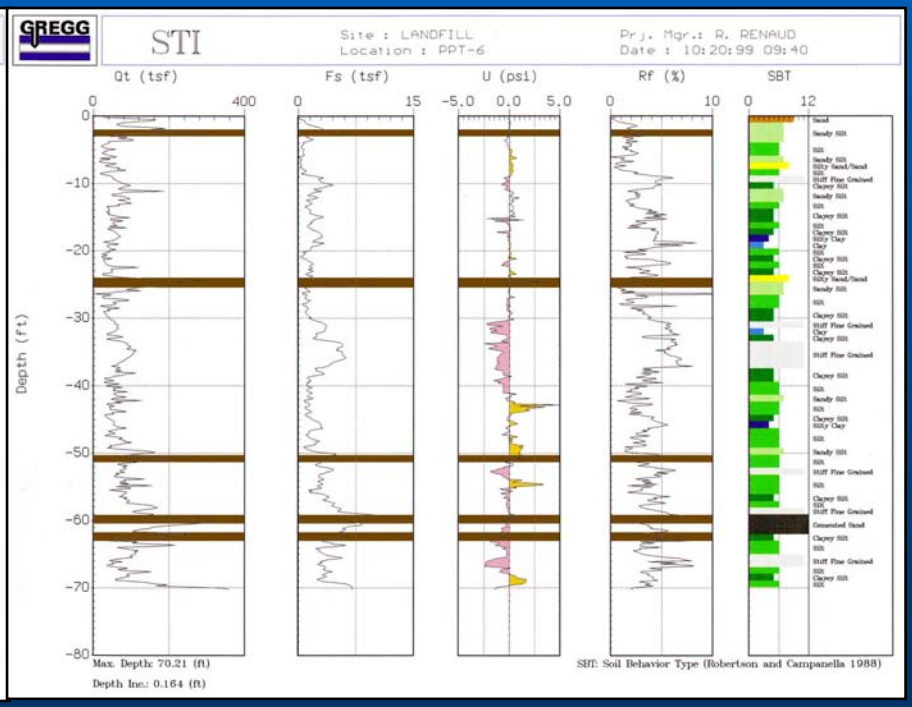
HYDROSTATIC PRESSURE SLOPE

- PPT Indicates Hydrostatic Liquid Pressure
- Interim Cover Layer at 40-ft Depth Causing Perched Water
- LFG Pressure Indicated Below Water Column



Gas Pressure/Vacuum Readings



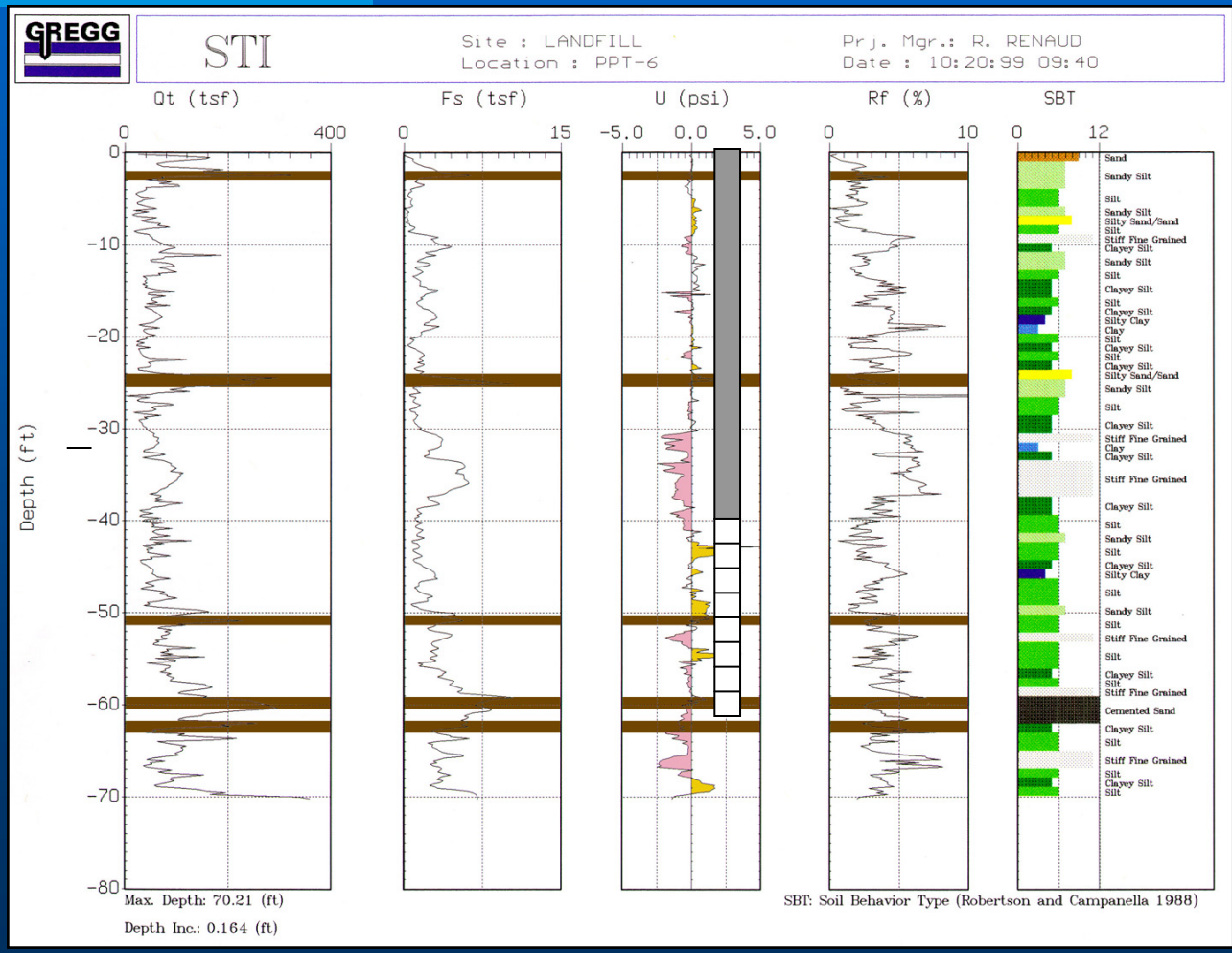


Internal Conduits

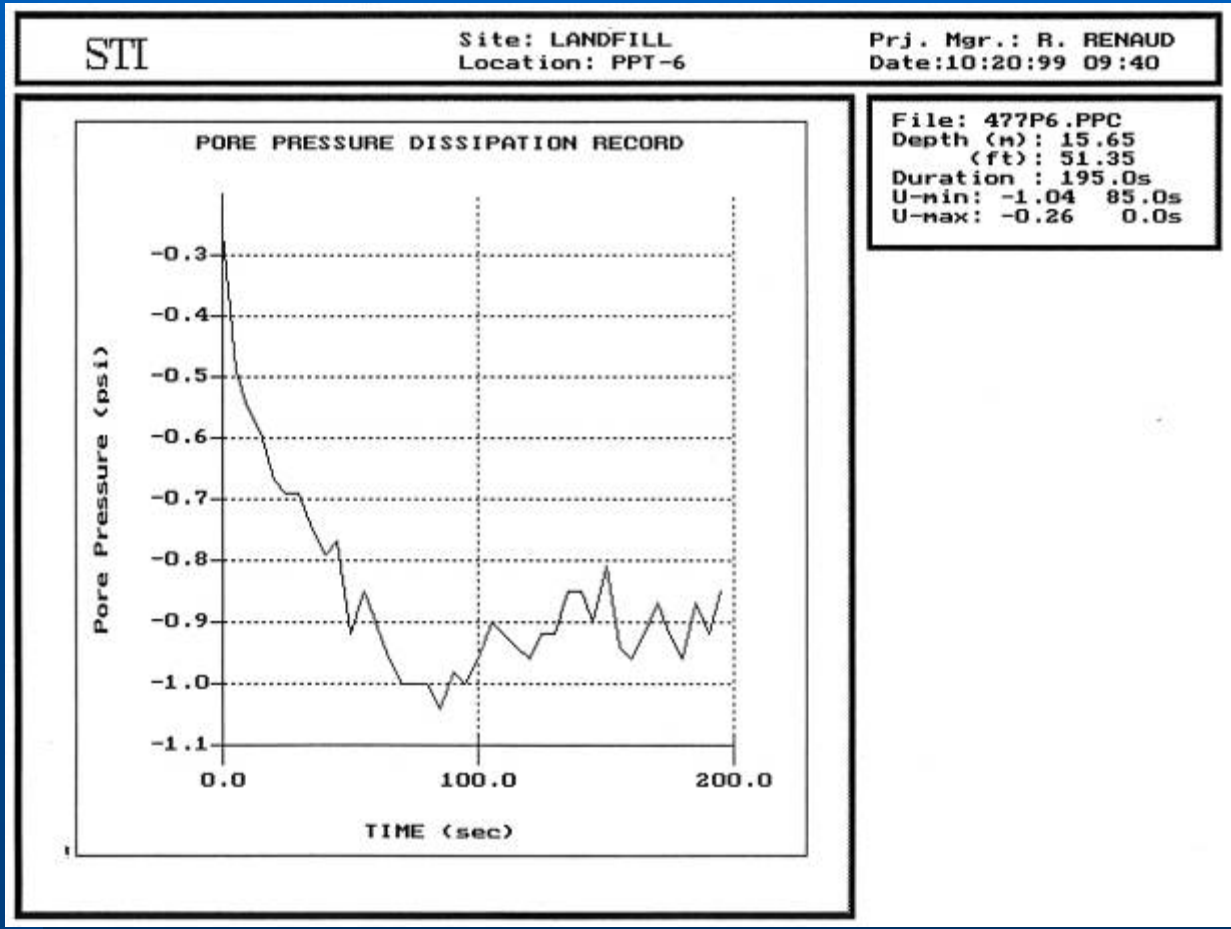
¾” PVC Slotted Pipe

Slots Connect Gas Layers to Vacuum Layers

The Hole Above the PVC Pipe is Grouted Up

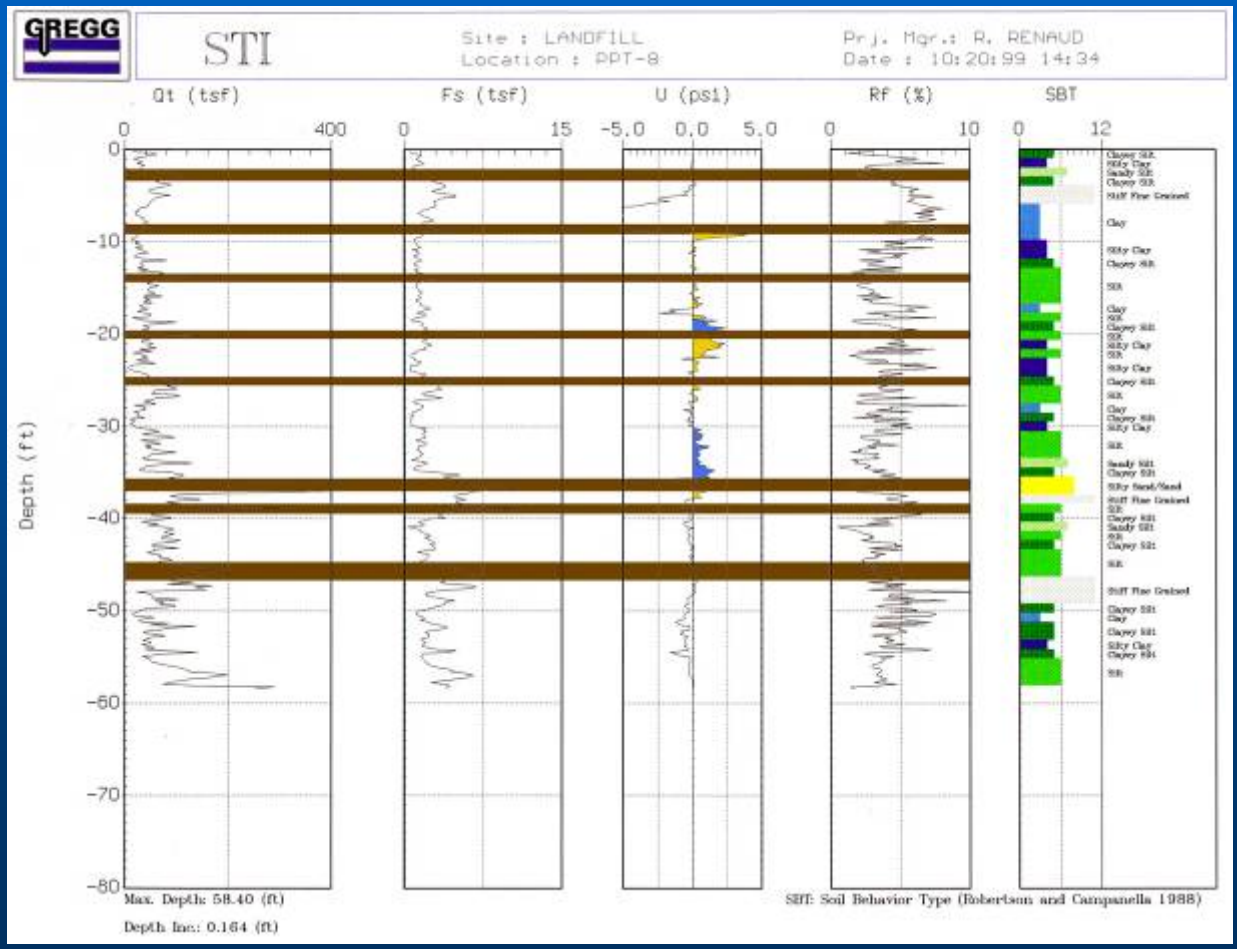


Stabilization of Vacuum



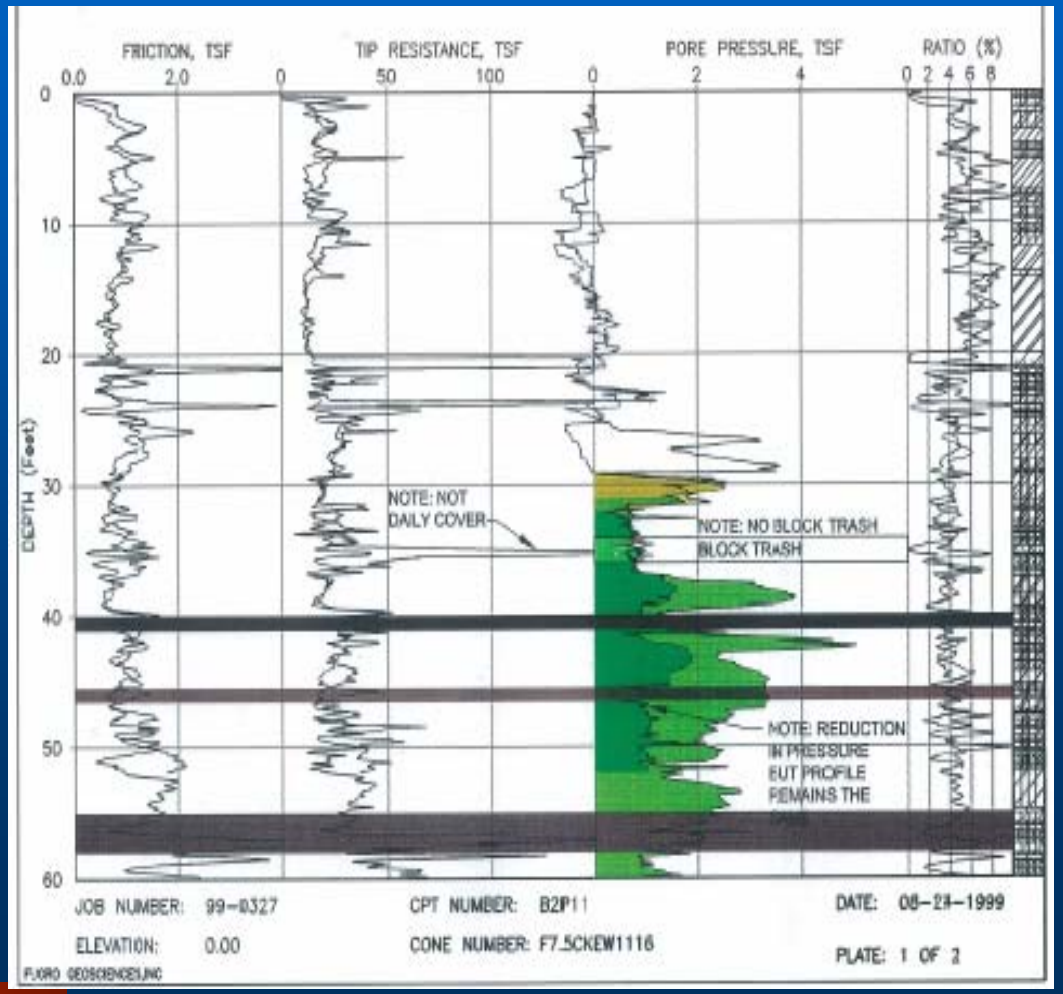
Identifying Liquid Layers

- Fewer Daily Cover Layers Minimizes Liquid Layers



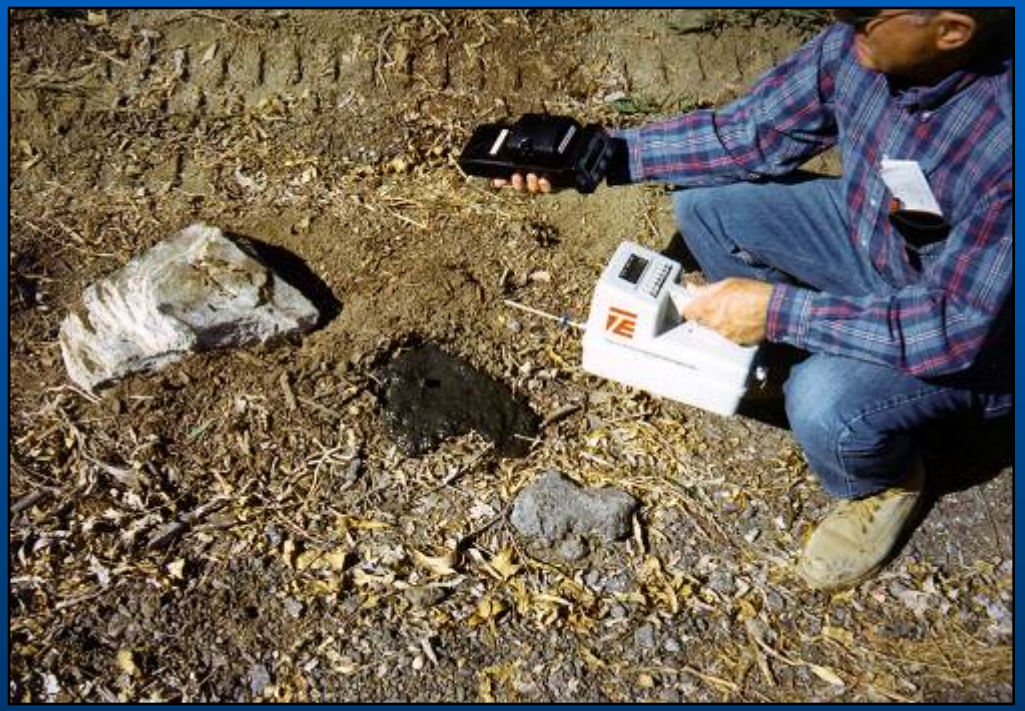
PPT Overlays

- Locations 5 Feet Apart
- PPT's Performed One Week Apart
- Pressure Reduced By Half
- Push-in Well Installed to Relieve Pressure



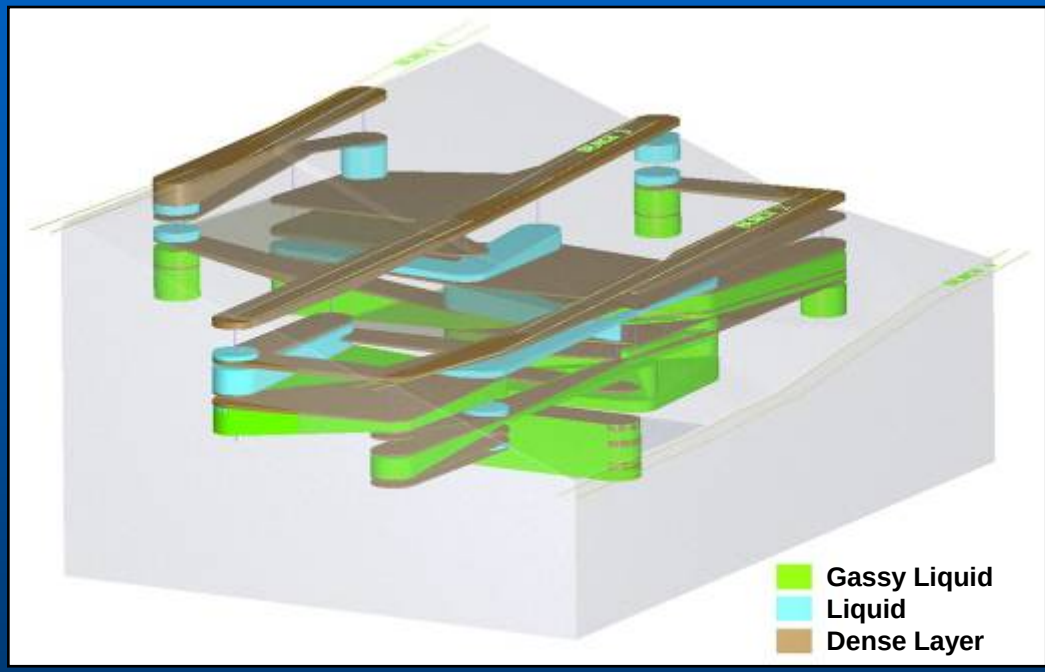
Field Observations Confirm Findings

- LFG “Effervesces” and Liquids Bubble from PPT Holes



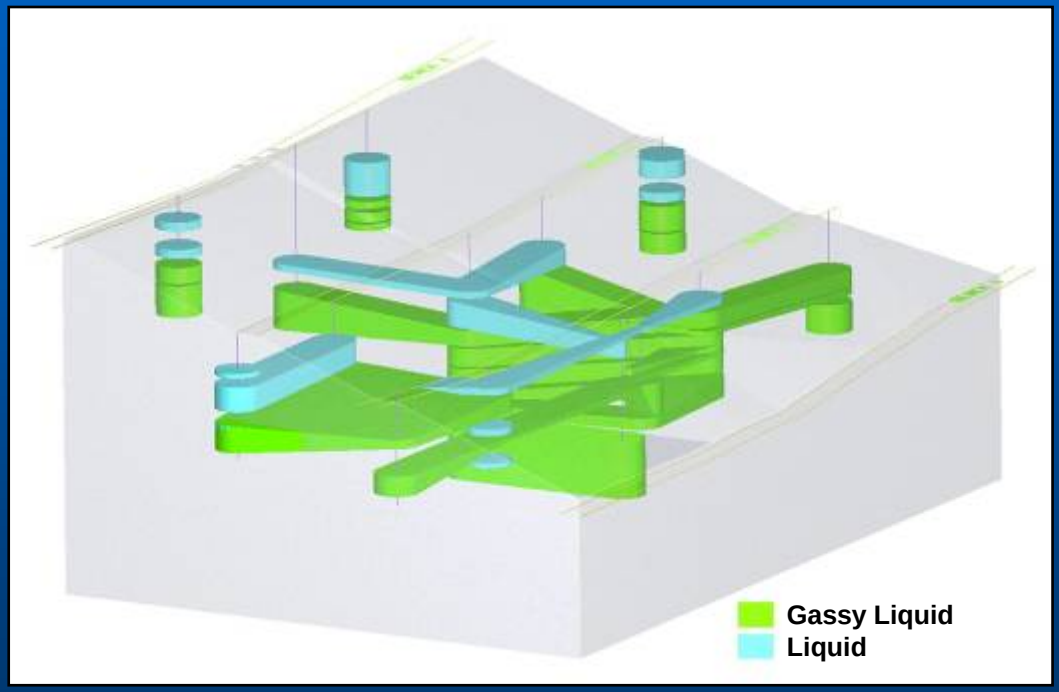
Building 3-D Profiles in Stages

- Liquids Trapped on Dense Layers
- Gassy Liquids Generally Trapped Between Dense Layers
- Continuity Between Liquid Layers Encountered Below Bench Roads

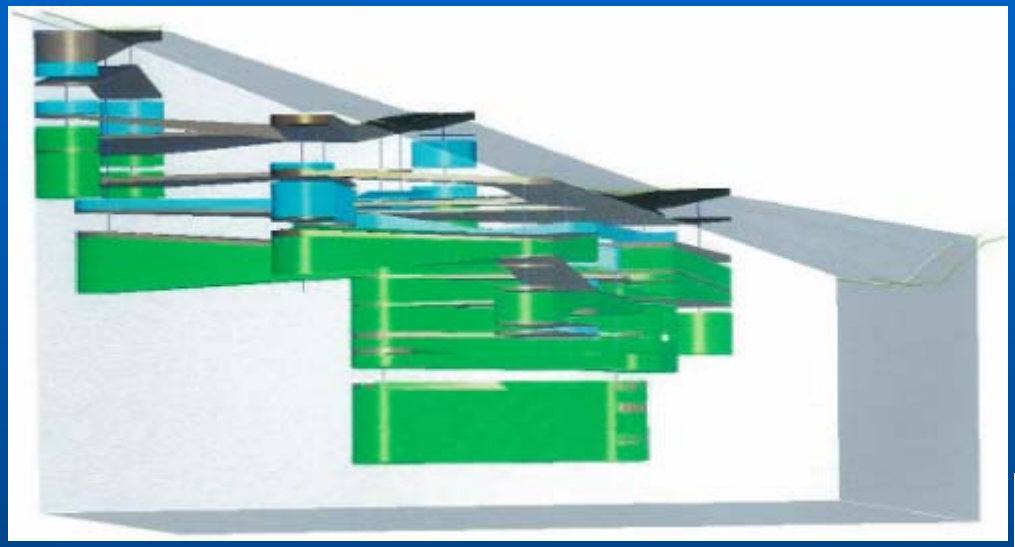


3-D Profile Enhances Understanding of Conditions

- Continuity of Liquid or Gassy Liquid Between and Along Bench Roads
- Liquids Above Gassy Liquids Indicates Water Intrusion

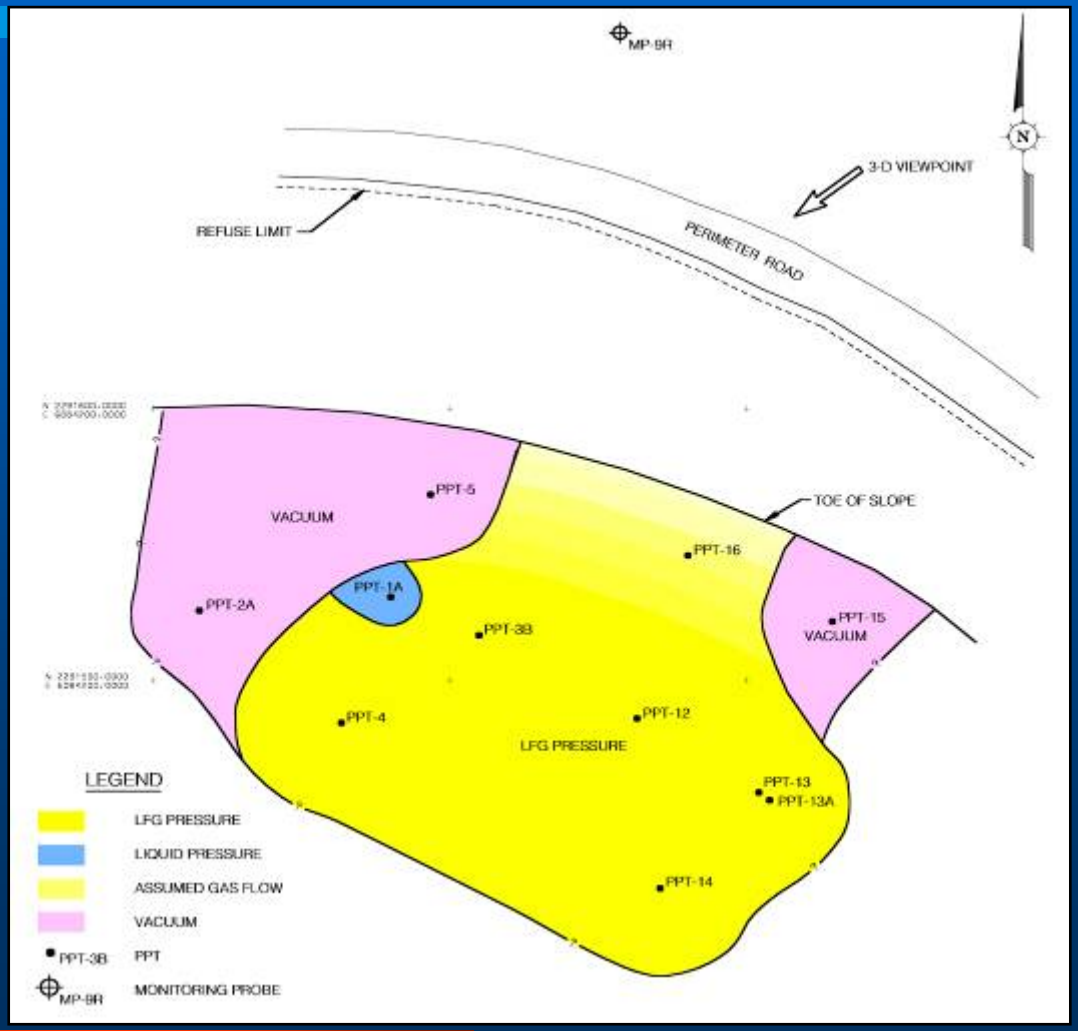


3-D Profiles Side View

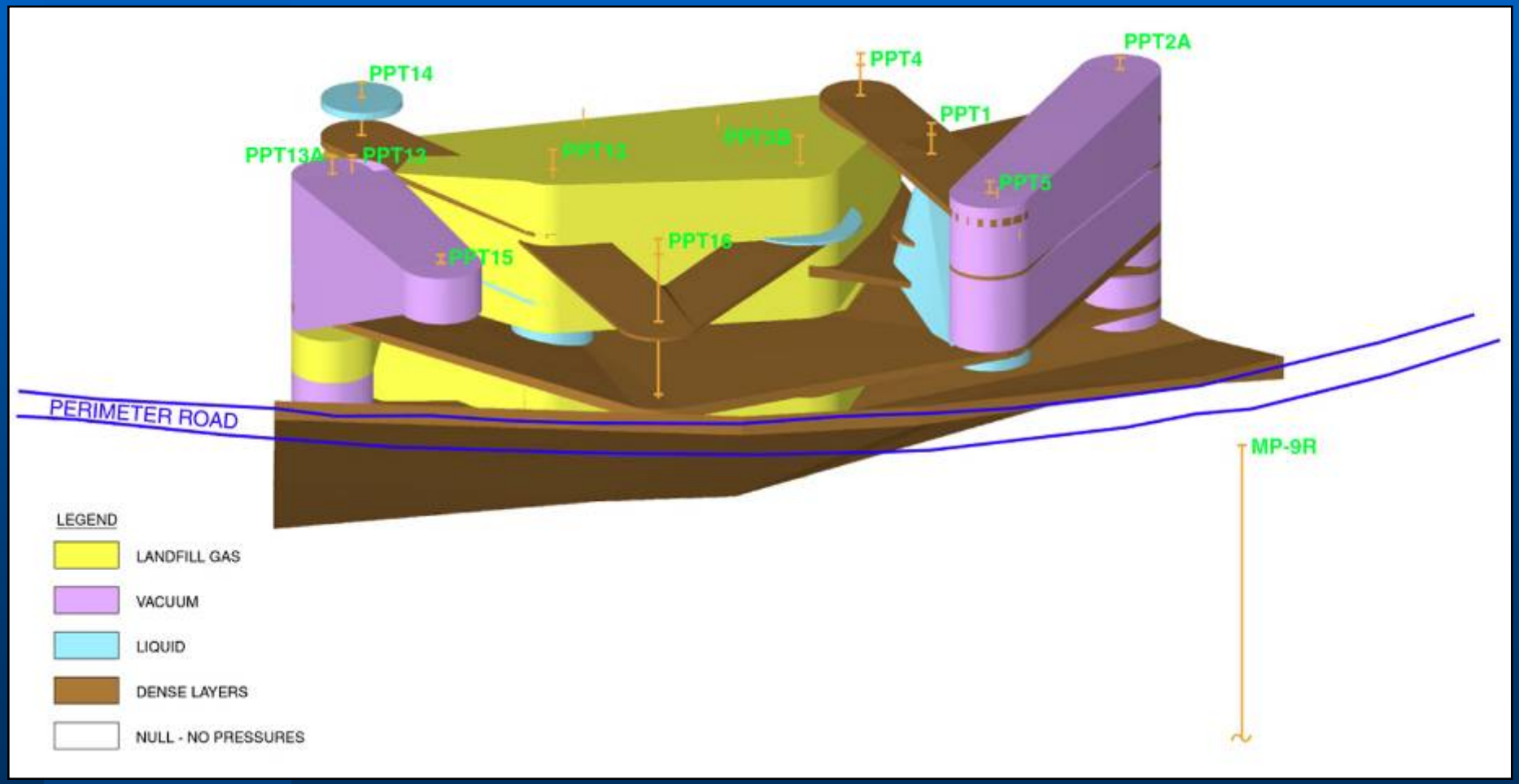


Landfill PPT Profiling

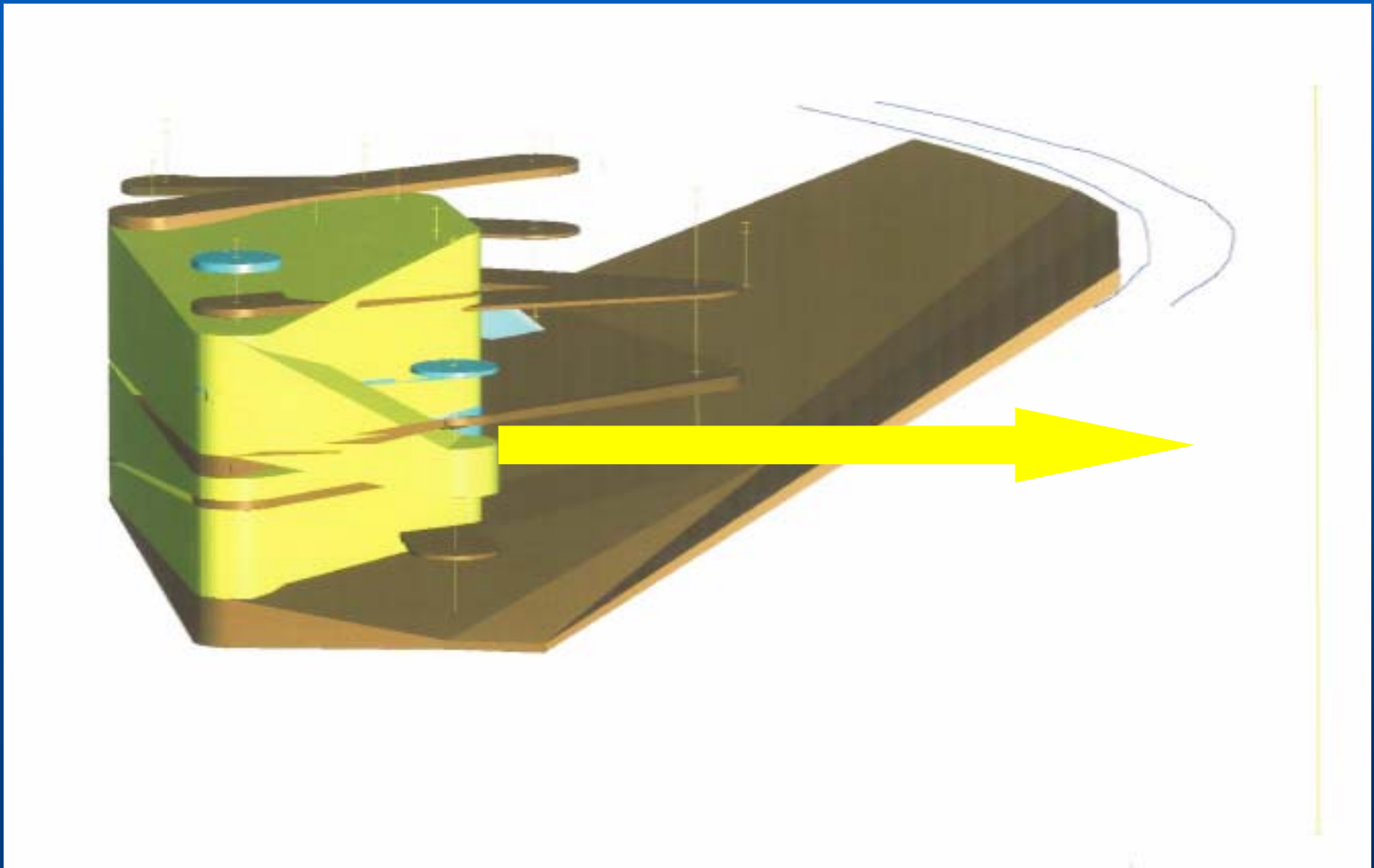
Landfill PPT Profiling Plan View



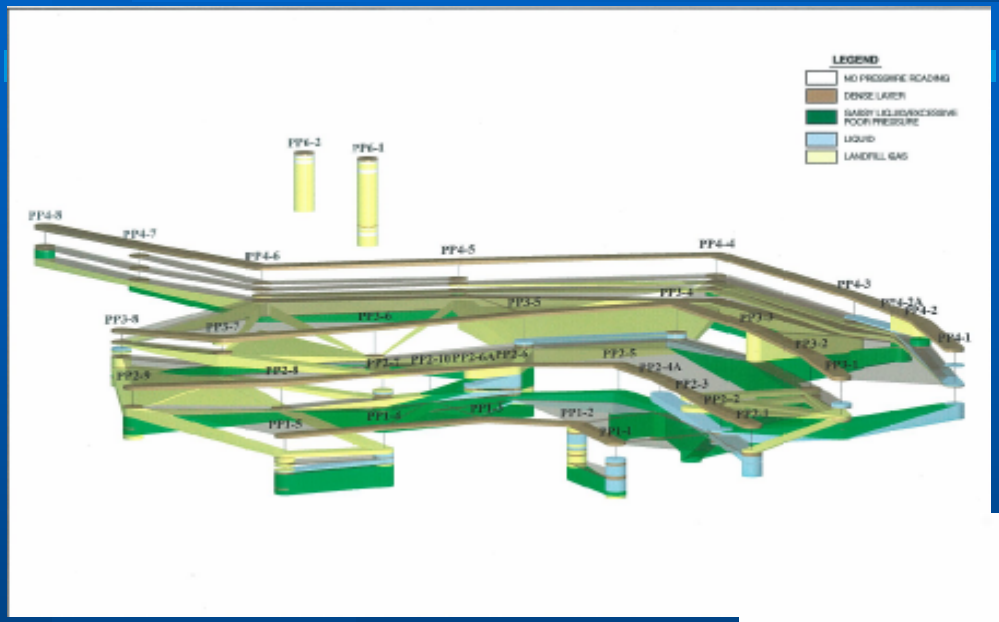
Landfill PPT Profiling
3-D Profile



Landfill PPT Profiling
Side View

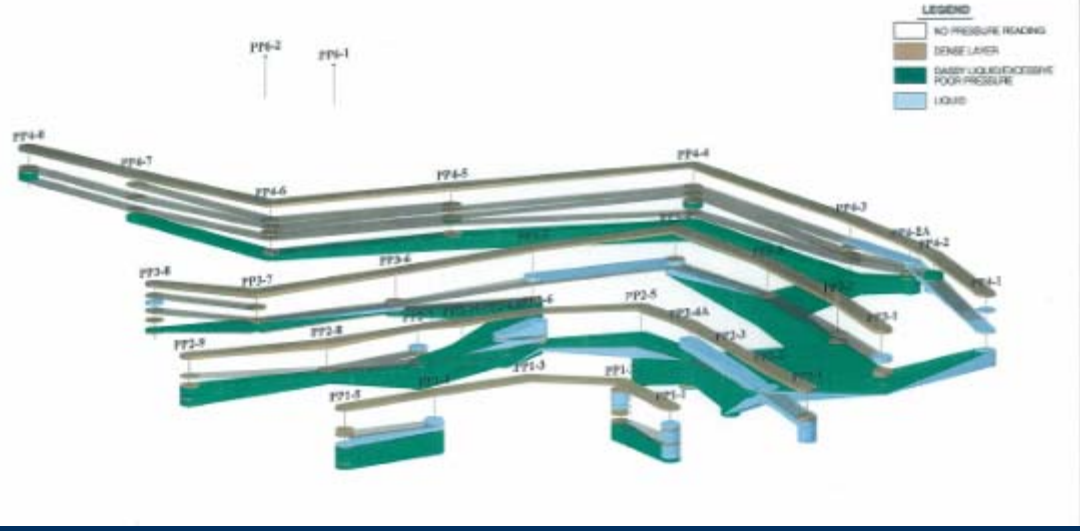


3-D Profiling With Colors On & Off

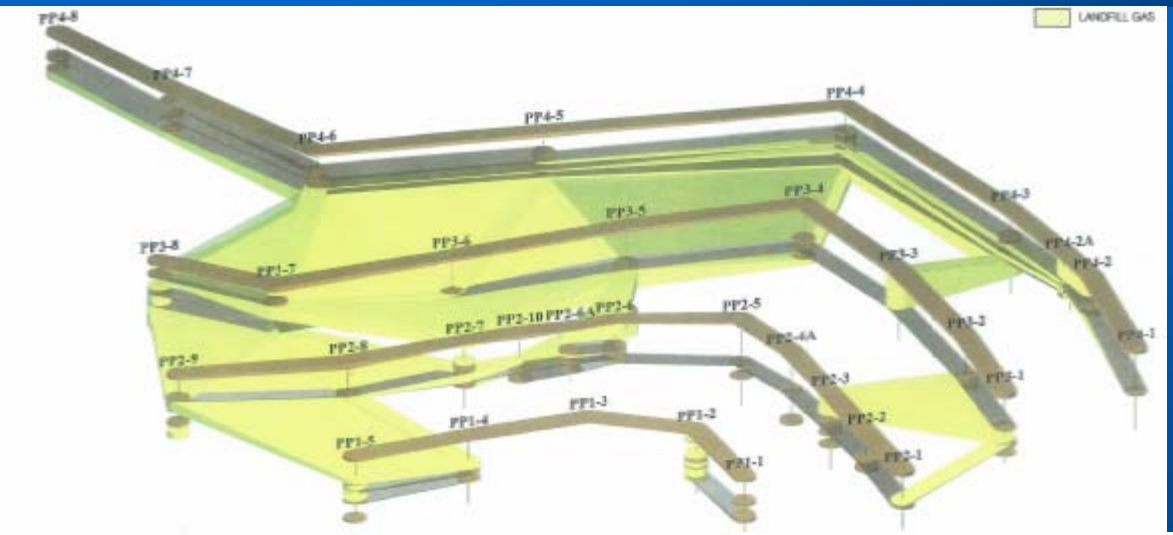


All Colors On

Gas Off

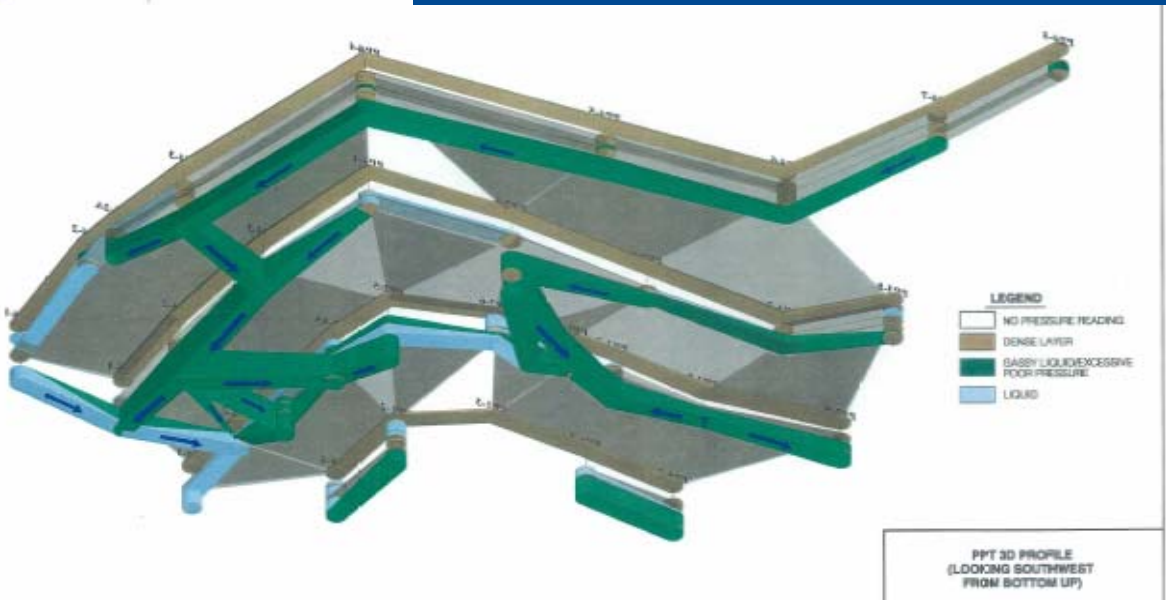


3-D Profiling



Gas Only

Water Gradient



What Can PPT Do For Your Landfills?

- Evaluate LFG Collection Coverage
- Investigate Reasons for Collector Failure
- Investigate LFG Pathway to “Hot” Probe
- Provide “Hard” Data for Design of Collectors
- Enhance Existing Collector Performance
- Add New Collectors
- Provide Data on System Performance Through Repeat Testing
- Rapid Response to LEA Notices

What Can PPT Do For Your Landfills?

- Avoid Installing Collectors Through Liquid Layers
- Evaluate Landfill For Use As Bioreactor
- Install Instrumentation In Landfills
- Evaluate and Install Perimeter Probes

Steam Injection Bioreactors
Miramar Landfill Pilot Study

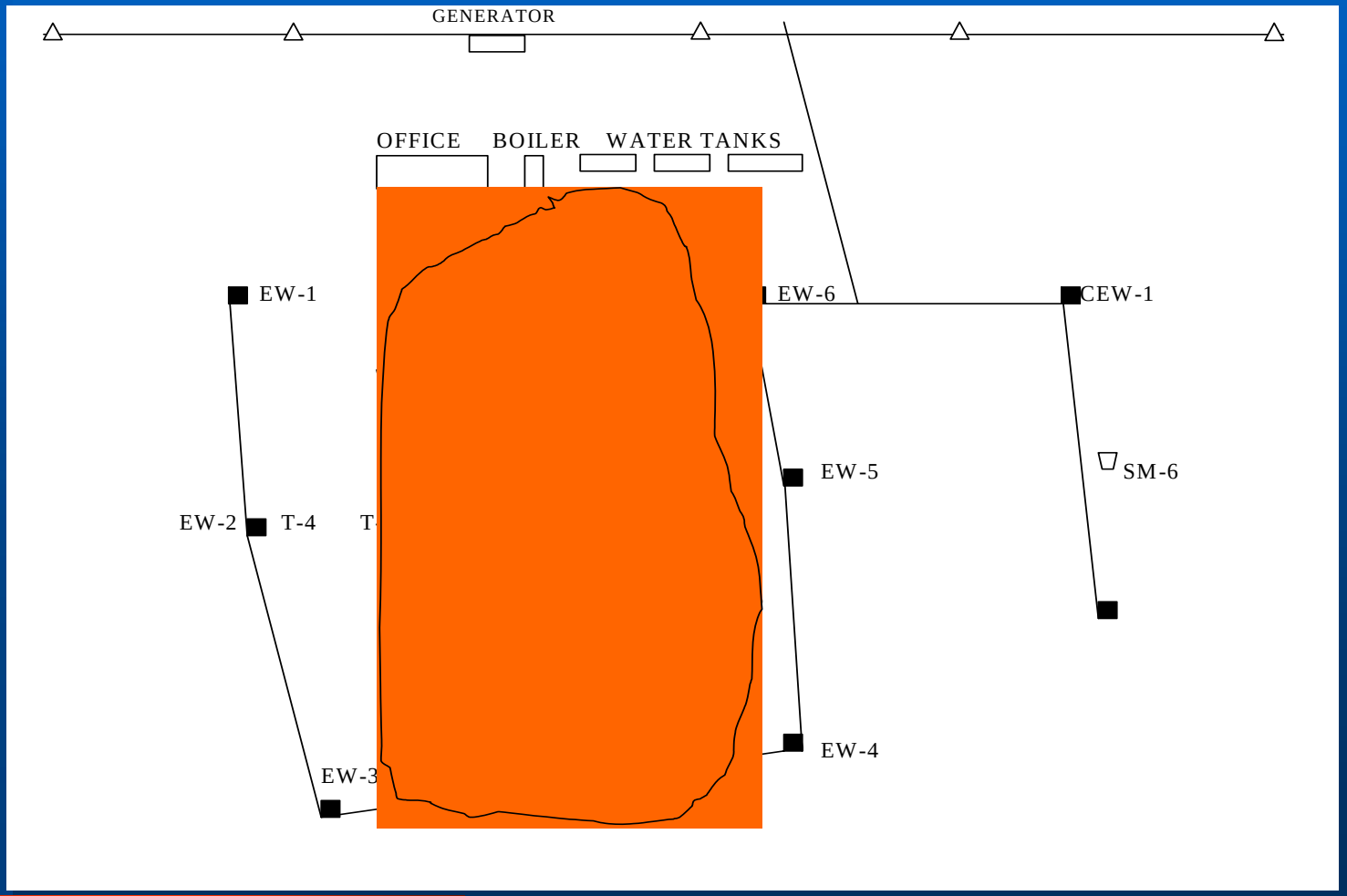
Miramar Landfill Pilot Study

2005 & 2006

Layout

- **4 Acres Were Profiled With The PPT**
- **1 Acre Was Chosen For The Study**
- **PPT Rig Installed**
  - 8 Collectors
  - 3 Injectors
  - 9 Thermocouples
  - 2 Static Piezometers
- **Collectors Were Connected To Existing Vacuum System**
- **6 Settlement Monuments Were Installed**

Site Layout Map



LFG Collector System

Steam Injector

Push-In Collectors & Injectors

- Wells and Injectors Are Pushed In, Not Drilled
- Following PPT The Hole Is Expanded To 3” Dia.
- 2” Dia. Black Steel Pipe
- Oilfield Mill Slots
- 10 Times The Open Space Than Drilled Holes
- No Cuttings Disposal
- 1/3 The Cost Of Drilled In Collectors
- Can Be Cleared With Steam

Four GPM Boiler

Steam Injection

Steam Injection Pipeline

Landfill Settlement

Miramar Landfill Pilot Study Objectives

- Determine If The Steam Migration Can Be Controlled By The LFG Collectors
- Determine If The Steam Can Heat Up & Moisten The Waste
- Determine If The Steam Increases Quality & Quantity Of Methane Gas
- Determine If Steam Injection Can Recover Airspace
- Determine If Leachate and Condensate Can Be Used In The Steam Process

Miramar Landfill Pilot Study
All Objectives Were Achieved

- By Increasing The Vacuum At The Collectors Steam Migration Was Indicated By The Thermocouples
- Thermocouples Indicated Increased Waste Temperature
- Methane Started At 54% Increased To 62%
- Test Cell Settled 26 Inches Near Injector # 2, In 7 Months
- Leachate and Condensate Was Used In The Steam Process

QUESTIONS?

- **Answer All Questions If Time Allows Today And/Or**
- **Contact:**

  - Reg Renaud

  - STI Engineering
  - P.O. Box 792, Silverado, CA
  - Phone: (714)649-4422
  - Web Site: www.landfillengineering.com
  - E-mail: regsti@msn.com